WATER QUALITY ASSESSMENT OF GORDON AND WERNER LAKES DISTRICT OF KENORA

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Ministry
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Environment

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The Honourable
William G. Newman,
Minister

Everett Biggs,
Deputy Minister

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WATER QUALITY ASSESSMENT

OF

GORDON AND WERNER LAKES

DISTRICT OF KENORA

1973

by
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Limnology & Toxicity Section
Water Resources Branch

Previously
Biology Section
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Ministry of the
Environment

135 St. Clair Avenue West
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Toronto Ontario
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November 6, 1973

M. Michalski

Dear Sir:

Provided herewith for your information is a copy of a report entitled 'Water Quality Assessment of Gordon and Werner Lakes, District of Kenora'.

The report, which presents the findings of a general water quality assessment of conditions in Gordon and Werner lakes, indicates only minor water quality alterations have occurred as a result of waste discharges from Consolidated Canadian Faraday Limited which commenced base metal mining and milling operations during 1962.

Mining operations at Werner Lake have now ceased and the milling operation is in its final phase with only custom milling of ore from an adjacent mine in Manitoba being carried out.

If you have any questions or comments related to the report or would like additional copies, please do not hesitate to contact this office.

Yours truly,

John H. Neil
Director
Water Quality Branch

encl.

SUMMARY

During 1971 an investigation of physical, chemical and biological conditions in Gordon and Werner lakes was undertaken in order to assess the influence of mine and mill waste discharges from the operations of Consolidated Canadian Faraday Limited.

Based on comparisons with reference stations on Werner Lake, the survey findings have revealed that only minor alterations of water quality and the aquatic community have occurred in the vicinity of the mine-mill complex as a result of ten years of operation. Water chemistry remained substantially unaltered with the exception of minor elevations in the dissolved solids, sulphate and nickel content in the immediate vicinity of the mine and mill discharges. At these same locations sediment levels of nickel, iron, copper and cobalt were elevated and minor modifications in the numbers and variety of bottom fauna were detected. Similarly the composition of the phytoplankton population was altered and densities greatly increased in Gordon Lake and at Station 6 on Werner Lake.

Perhaps the most significant finding of the study was the presence of whitefish and walleye in Gordon Lake. Based on the assumption that Gordon Lake would become grossly polluted, an attempt was made prior to development of the ore body to remove fish from the lake. The residual population has survived, appears to have multiplied in numbers and those specimens captured, appeared to be in excellent condition.

The findings of this study are surprising in view of the results of similar investigations in other areas of Ontario which have revealed

serious water quality problems associated with mining and milling operations which seemingly had better control of their waste discharges and more sophisticated treatment facilities.

While the existing waste treatment and containment facilities appear to be functioning adequately, the situation at Gordon Lake and Werner Lake will be assessed periodically to ensure that water quality impairment does not materialize with further passage of time.

INTRODUCTION

In conjunction with an industrial wastes survey of the base metal mining and milling operations of Consolidated Canadian Faraday Limited at Werner Lake in the District of Kenora, a water quality evaluation of Gordon and Werner lakes was undertaken during June, 1971. The purpose of the study was to determine the influence of mining and milling wastes from the aforementioned operations on the water quality and associated life of Gordon and Werner lakes.

GENERAL DESCRIPTION OF STUDY AREA

Gordon and Werner lakes are located approximately 50 air miles northwest of Kenora in unorganized territory in the District of Kenora. The lakes are situated 12 miles east of the Manitoba boarder and are accessible by land only via Highway 315 from Lac du Bonnet in Manitoba.

Gordon lake occupies an area of 250 acres on a plateau some 60 feet above the surface of Werner lake. Maximum depth of the lake is 65 feet. Werner lake lies in a narrow eastwest trough of about five miles in length and has, at its deepest point, a maximum depth of 55 feet. Grant Lake, which was also examined as part of the study. is a shallow glacial basin with a maximum depth of 35 feet.

Drainage of the study area is from Gordon Lake to Werner Lake to Grant Lake. From Grant Lake, the flow is through the Werner River into Umfreville Lake, the English River and evantually the Winnipeg River.

Owing to the isolated nature of the mining camp and the splendid aesthetic features of Gordon and Werner lakes, much of the recreational activities of the townsite inhabitants focus on Gordon and Werner lakes. Both are utilized for swimming, boating and angling. Walleye, northern pike and whitefish are the important fish species indigenous to these waters.

The Townsite of Werner Lake is situated approximately 3/4 of a mile west of the mill. In addition to the townsite, several company homes are situated around the mill site and on a small island in Gordon Lake.

Industrial wastewaters from the mining and milling operations at Werner Lake which commenced in 1962 are discharged to Gordon and Werner lakes. A complete description of these activities is contained in a 1972 Industrial Wastes Branch report entitled 'An Industrial Wastes Survey of Consolidated Canadian Faraday Limited, Werner Lake Division'. For purpose of this report the operation can be described as consisting of the conventional underground mining of approximately 250 tons per day of ore and surface milling at a rate of 1,100 tons per day for recovery of copper and nickel concentrate. The difference in mining and milling rates is explained by the fact that the milling operation of Consolidated Canadian Faraday Limited at Werner Lake undertakes custom milling of ore transported to the site from an adjacent mining operation in Manitoba.

The company withdraws about 511,000 Imperial gallons per day of water for domestic and industrial usage. Water required for mill processes is pumped from Gordon Lake at a capacity of 424,500 gallons per day and that required for use in the mine and for domestic purposes is pumped from Werner Lake at the capacity of 86,400 gallons per day.

Wastewater arising from milling operations consists of a slurry of process water and finely ground residue of the ore after the metal concentrates have been extracted. This slurry, commonly known as mill tailings, is discharged from the mill to a 30 acre portion of Gordon Lake which is impounded by two waste rock dams extending from the mainland to an island in the lake.

Mine wastewater consisting of about 58,400 gallons per day of water used underground for industrial and domestic purposes and approximately 91,600 gallons per day of ground water infiltration is pumped to surface and discharged to Werner Lake.

METHODS

Field work for the present study was undertaken on June 22, 23 and 24, 1971. With exception of the fish which were taken from a single netting in Gordon Lake, all of the samples were secured from eight sampling sites illustrated in Figure I.

Water Chemistry

Water samples collected for detailed chemical analyses were taken at ten-foot intervals from surface to bottom at each sampling site by means of a Kemmerer sampler. Samples for heavy metals analyses were collected in plastic containers and preserved with nitric acid at the time of sampling. All other samples for chemical analyses were collected in glass bottles with no preservative added.

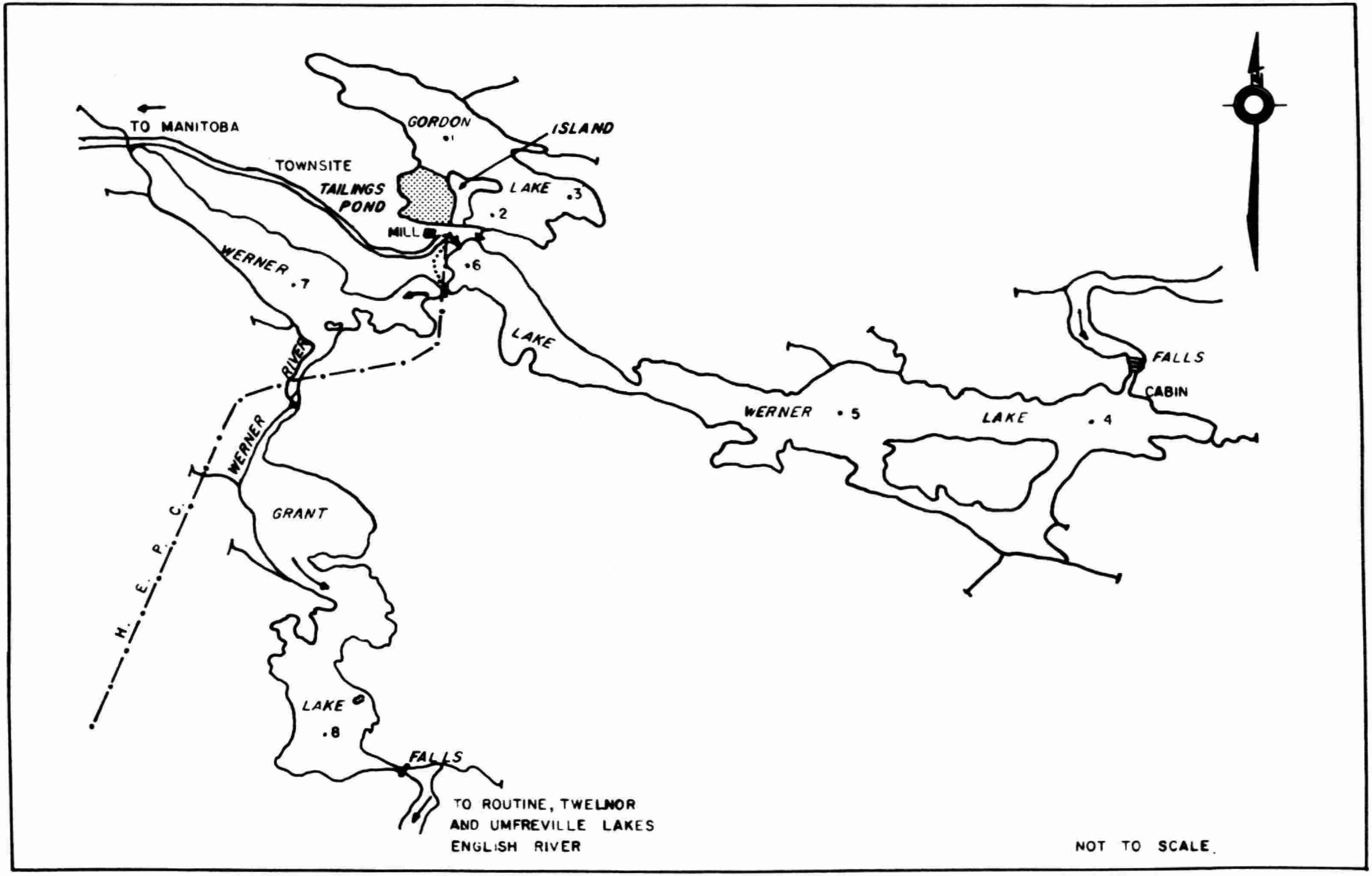

Figure 1: Gordon-Werner Lakes

In addition to sampling for detailed laboratory analyses, on-site measurements of water transparency, temperature and dissolved oxygen were made. Water transparency was determined by means of a Secchi disc. Temperature determinations were made with a telethermometer. Dissolved oxygen readings were determined using the azide modification of the Winkler Method.

Phytoplankton

Composite samples from the euphotic zone (twice the Secchi disc reading) were collected at each station. Samples were preserved with Lugol's iodine solution and submitted to the Biology laboratory for identification and enumeration.

Bottom Fauna

Five replicate samples of the benthic community were secured at each sampling location with a Ponar dredge. Samples so obtained were washed through a 24 mesh-per-inch (0.0256 inch opening) box-screen. Organisms retained by the screen were picked into vials of ethanol and returned to the laboratory for identification and enumeration.

Fish

A single set of gill nets was made on June 23 and retrieved on June 24th. All fish captured were recorded and then forwarded to Chemistry II Branch at the Toronto Laboratory for heavy metals analyses.

SURVEY FINDINGS

Water Chemistry

Table I of the Appendix provides the data derived from on-site determinations of temperature, transparency, dissolved oxygen and pH. These data characterize all three lakes as having only moderate thermal stratification, a slight hypolimnetic oxygen deficit, pH's on the alkaline side of neutrality and reasonably good water clarity. It should be noted that control stations 4 and 5 did not exhibit a hypolimnetic oxygen deficit. As a further point of interest, stations I, 2 and 3 on Gordon Lake exhibited an increase in pH with depth whereas a reciprocal pH relationship was evident in Werner and Grant lakes. The significance of these findings is not readily evident.

The analytical results of water samples submitted to the laboratory for chemical analyses are provided in Table 2 of the Appendix. Most chemical parameters remained relatively uniform at the eight sampling locations. The only parameters which appear to have been altered as a result of mine-mill mill waste water inputs were dissolved solids, particularly the sulphates and nickel.

Dissolved solids values ranged from I9 to 64 mg/l at the control station 4 and 5 on Werner Lake. Gordon Lake, which received the mill-waste discharge had slightly higher dissolved solids levels ranging between 69 and I44 mg/l. Station 6 on Werner Lake, which receives the overflow from Gordon Lake and the direct input of mine water, had significantly elevated dissolved solids values ranging from 73 to 474 mg/l.

At the control sites 4 and 5, sulphate levels were consistently measured at less than 5 mg/l, the typical value for surface waters in the Pre-Cambrian Shield. Considerably higher sulphate values were measured at Stations 1 to 3 on Gordon Lake. These values ranged from 46 to 54 mg/l. At Station 6 on Werner Lake, sulphates ranged in concentration from 7 to 29 mg/l. The higher values in Gordon Lake reflect the conversion of sulphides in the tailings to sulphates.

Nickel concentrations reached a maximum of 120 ppb at Station 6 on Werner Lake. In Gordon Lake the concentration of nickel was similarly elevated to a maximum value of 80 ppb. No elevation in concentrations of other heavy metals was detected.

It is interesting to note that ammonia levels remained substantially unaltered in Gordon and Werner lakes. This finding is somewhat surprising in that ammonia toxicity is frequently a problem associated with mine-mill wastes.

The reason ammonia toxicity is not a problem at Werner Lake relates to the fact that ammonia is not utilized within the mill for purposes of maintaining pH control within the milling circuits. The only source of ammonia at Werner Lake is thought to be from the use of ammonium nitrate explosives in the mining operation. Ammonia was detected in the mine water discharge at concentrations ranging between 1 and 2 ppm. The low volume of mine-water discharge combined with the dilution provided in Werner Lake, readily accounts for the low ammonia levels detected in the receiving water.

Sediment Chemistry

Sediment samples secured from each of the sampling sites were submitted to the laboratory for heavy metals analyses. The results are provided in Table 3 of the Appendix.

During the early phases of development at Werner Lake, tailings from the milling operation were discharged directly to Gordon Lake without containment. Visual inspection of the sediments in Gordon Lake showed tailings to occur throughout the lake sediments. Chemical analyses confirmed this observation. In comparison to the metal content of the control stations, sediments of Gordon Lake and Station 6 on Werner Lake contained substantial quantities of nickel, copper and iron and slightly higher levels of cobalt. As revealed through the water chemistry, nickel appears to constitute the major metal input to the system. Nickel concentrations in the sediments were elevated from approximately 50 ppm at the control site to a maximum of 1520 ppm in Gordon Lake and 1134 ppm at Station 6 on Werner Lake.

Fish Flesh Chemistry

A small sample of fish consisting of three walleye and eight whitefish was obtained from Gordon Lake for purposes of determining body burdens of heavy metals.

It is interesting to note that the fish obtained from Gordon Lake were mature specimens of seemingly excellent condition. Prior to commencement of mining operations at Werner Lake, a permit was issued to a commercial fisherman to remove fish from Gordon Lake since it was felt that the mining operations would have an adverse effect on the fish population. It is therefore significant that the small residual population of whitefish and walleye have been able to survive and re-populate the lake despite the continuous discharge since 1962 of mill wastes to the relatively small lake.

The information obtained from chemical analyses of the fish secured from Gordon Lake cannot be related to the mining activities owing to the absence of a control sample. The results are important, however, for comparison with values obtained from other areas of the Province such as those reported from the Manitouwadge chain of Lakes (German, 1972).

Analyses of the walleye muscle revealed mercury levels somewhat in excess of the 0.5 ppm level considered safe for human consumption. Whitefish,specimens, however, all contained less than 0.5 ppm mercury in their flesh.

Zinc, which was the most prevalent metal encountered in both species, occurred in the highest concentrations in skin and scale samples. The intestines, liver and brain samples, all contained relatively high levels of zinc whereas the muscle samples contained relatively low concentrations of zinc.

Copper was detected in the skin, scales and liver of walleye. In the whitefish, copper was concentrated to the greatest extent in the intestines and liver with only traces of copper in the skin and scales.

Lead, nickel and cadmium, with a few minor exceptions, appeared to be confined to the skin and scales of the fish.

Bottom Fauna

Results of the bottom fauna survey are provided in Table 4 of the Appendix. The effect of inorganic pollution on the benthic fauna does not elicit a characteristic community response of selective elimination of certain species and increased densities of tolerant forms, rather it only further restricts the species diversity and the numbers of organisms. For this reason, assessment of mine waste contamination in the Northern Ontario lakes is particularly difficult owing to the naturally unproductive nature of Pre-Cambrian waters.

Station 5 on Werner Lake, one of the control sites, produced the most diverse benthic community with six taxa and a density of 40 organisms per square foot. Presence of pollution-sensitive organisms, such as the mayfly Hexagenia, amphipod Pontoporeia affinis and decapod Mysis relicta illustrated the excellent water quality at Station 5.

Gordon Lake produced a total of six taxa but fewer numbers of organisms than found at the control stations. The absence of pollution-sensitive forms was one of the notable features of the Gordon Lake benthic community. This factor and the low density of organisms suggests some pollutional influence. However, it is probable that the factor influencing the community was the occurrence of tailings in the sediment rather than a water quality effect.

Phytoplankton

Standing crops of phytoplankton were surprisingly high relative to the low phosphorus and nitrogen values present in the water. Stations 2 and 3 on Gordon Lake contained the highest stocks at 1666 and 2106 areal standard units, respectively. Station 6 on Werner Lake had a moderately high crop of 702 units. The control stations 4 and 5 on Werner Lake contained much lower densities of 314 and 293 areal standard units..

The diatoms Asterionella, Fragillaria and Synedra were dominant in Gordon Lake whereas the blue-green alga Gomphosphaeria was dominant at Station 6 on Werner Lake and flagellates dominated the phytoplankton at the control stations.

References

Ministry of the Environment. 1972. An Industrial Wastes Survey of Consolidated Canadian Faraday Limited, Werner Lake Division.

German, M.J. 1972. Effects of Acid Mines Wastes on the Chemistry and Ecology of Lakes in the Manitouwadeg Chain, District of Thunder Bay. Ministry of the Environment.

Table 1 Physico-chemical data collected on Gordon, Werner and Grant Lakes, June 22-23, 1971

Station	Secchi Disc in ft.	Sample Depth in ft.	pH	Dissolved ppm	Oxygen % Saturation	Temperature °C	°F
1	6.0	0	7.0	7	65.8	18	64
		10	7.2	6	58.9	16	61
		20	7.2	6	65.6	11	52
		30	7.1	5	58.6	8	46
		40	7.2	5	60.1	7	45
		50	7.4	4	48.2	7	45
		60	7.4	3	36.3	7	45
2	7.0	0	7.2	7	67.2	17	63
		10	7.4	7	67.2	17	63
		25	7.4	5	57.3	9	48
3	8.0	0	7.1	7	65.9	18	64
		10	7.1	6	56.6	18	64
		20	7.3	5	54.8	11	52
		30	7.4	4	48.2	7	45
4	5.0	0	7.3	7	63.3	20	68
		10	7.2	6	55.4	19	66
		20	7.1	6	60.2	15	59
		30	7.1	6	65.6	11	52
		40	7.0	6	67.1	10	50
		45	7.0	6	67.1	10	50
5	5.0	0	7.2	6	55.4	19	66
		10	7.1	6	56.6	18	64
		20	7.0	6	62.8	13	56
		30	7.0	6	65.6	11	52
		40	7.0	6	68.6	9	48
		50	7.0	6	68.6	9	48
		55	7.0	6	68.6	9	48
6	5.0	0	7.2	6	55.4	19	66
		10	7.2	6	64.1	12	54
		20	7.1	6	64.1	12	54
		25	7.1	5	56.5	10	50
7	6.0	0	7.3	6	55.4	19	66
		10	7.3	6	56.6	18	64
		20	6.5	3	31.6	13	56
8	6.5	0	7.3	7	64.5	19	66
		10	7.2	6	55.4	19	66
		20	6.7	6	62.8	13	56
		30	6.7	4	44.9	10	50
		35	6.7	3	34.5	9	48

Table 2 Results of Chemical analyses made on water samples collected from Gordon Werner and Grand Lakes, June 23, 1971. All values except pH and turbidity reported as parts per billion.

Station	1							2			3			
Analyses Depth	0'	10'	20'	30'	40'	50'	60'	0	10	20	0	10	20	30
Total Solids	125	115	115	105	110	140	130	100	125	105	70	95	145	110
Suspended Solids	1	1	1	1	1	5	2	1	1	2	1	1	1	1
Dissolved Solids	124	114	114	104	109	135	128	99	124	103	69	94	144	109
Turbidity Units	1.1	1.2	.9	.8	.8	1.4	2.2	.8	.7	1.5	.8	.8	1.1	1.2
Free Ammonia	.00	.00	.05	.04	.05	.08	.23	.00	.00	.03	.00	.00	.03	.05
Total Kjeldahl	.46	.34	.36	.34	.36	.45	.54	.34	.34	.37	.32	.35	.37	.35
Nitrite	.005	.005	.004	.004	.005	.005	.006	.005	.005	.004	.004	.005	.004	.004
Nitrate	<.01	<.01	.02	.04	.05	.05	.05	.01	<.01	.03	.01	.01	.02	.03
Total Phosphorus	.011	.011	.011	.027	.035	.034	.033	.009	.008	.010	.011	.009	.025	.008
Soluble Phosphorus	.001	.001	.002	.002	.004	.020	.005	.001	.001	.001	.001	.002	.002	.005
Hardness	48	50	48	52	50	52	54	46	46	52	46	48	46	54
Alkalinity	24	24	24	26	26	28	30	24	24	26	24	24	24	26
Iron	.15	.15	.20	.25	.20	.25	.20	.15	.15	.25	.20	.15	.20	.30
Acidity	4	4	6	6	6	6	6	2	4	6	4	2	6	6
pH	6.9	6.9	7.0	7.0	7.0	7.0	7.0	7.0	6.9	6.9	7.2	7.2	7.1	6.9
Sulfate	50	50	46	51	50	52	54	50	48	52	48	47	50	52
Calcium	10	10	10	11	11	11	12	10	10	10	10	10	10	11
Magnesium	5	6	5	6	5	6	6	5	5	6	5	5	5	6
Conductivity	198	196	196	212	210	214	224	200	199	210	197	199	200	213
Sodium		17							16			17		
Potassium		4.5							4.5			4.3		

Table 2 cont'd

	1							2			3			
Analyses	0	10	20	30	40	50	60	0	10	20	0	10	20	30
Zinc ppb	20	20	20	10	20	80	20	<0.05	<0.05	30	<0.05	<0.05	<0.05	<0.05
Copper ppb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel ppb	80	20	40	<0.05	60	70	<0.05	50	30	70	5	30	50	70
Lead ppb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium ppb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cobalt ppb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese ppb	20	30	30	50	40	40	100	30	20	60	<0.05	10	20	60

Table 2 cont'd.

	4						5						
Analyses	0	10	20	30	40	47	0	10	20	30	40	50	57
Total Solids	40	20	30	30	45	55	65	70	60	35	60	50	30
Suspended Solids	1	1	1	2	1	2	1	2	1	2	2	1	5
Dissolved Solids	39	19	29	28	44	53	64	68	59	33	58	49	25
Turbidity Units	1.4	1.4	1.2	1.1	1.2	1.5	1.3	1.5	.9	.8	1.0	1.1	1.7
Free Ammonia	.02	.02	.03	.03	.02	.01	.00	.00	.01	.03	.02	.03	.02
Total Kjeldahl	.51	.44	.46	.42	.48	.46	.35	.43	.38	.34	.41	.36	.46
Nitrite	.007	.007	.007	.007	.007	.007	.006	.007	.007	.007	.007	.007	.007
Nitrate	<.01	<.01	<.01	.01	.01	<.01	<.01	<.01	.01	.01	.02	.02	.02
Total phosphorus	.028	.015	.016	.014	.021	.020	.011	.016	.013	.009	.015	.017	.030
Soluble phosphorus	.002	.002	.003	.004	.003	.003	.002	.002	.002	.006	.007	.004	.003
Hardness	14	18	16	16	18	18	16	16	20	18	18	16	20
Alkalinity	11	9	11	9	11	9	9	9	9	9	9	11	9
Iron	.35	.35	.35	.50	.50	.65	.30	.30	.40	.35	.45	.50	.70
Acidity	6	2	6	6	8	8	4	4	6	6	6	8	8
pH	6.5	6.8	6.8	6.6	6.6	6.6	6.6	6.6	6.5	6.6	6.5	6.5	6.5
Sulfate	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Calcium	4	4	4	5	5	6	4	4	5	5	5	5	6
Magnesium	1	2	1	1	2	1	1	1	2	1	1	1	1
Conductivity	40	40	49	50	54	55	42	44	55	50	53	54	58
Sodium		2						3					
Potassium		0.8						0.8					

Table 2 cont'd

		4						5						
Analyses		0	10	20	30	40	47	0	10	20	30	40	50	57
Zinc	ppb	7	9	5	17	20	20	7	4	<0.05	8	7	6	10
Copper	ppb	13	5	9	7	<0.05	<0.05	<0.05	<0.05	<0.05	9	9	7	15
Nickel	ppb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead	ppb	4	4	3	4	0	0	0	0	0	7	6	7	8
Cadmium	ppb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cobalt	ppb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese	ppb	13	11	10	11	20	10	<0.05	3	<0.05	8	10	15	19

Table 2 cont'd

			6			7					8	
Analyses	0	10	20	25	0	10	20	0	10	20	30	36
Total Solids	75	165	360	475	70	90	80	80	80	85	80	75
Suspended Solids	2	1	1	1	1	1	5	2	1	2	1	2
Dissolved Solids	73	164	359	474	69	89	75	78	79	83	79	73
Turbidity Units	1.3	1.2	1.4	1.9	1.4	1.6	2.0	1.4	1.6	1.2	1.2	2.3
Free Ammonia	.00	.01	.02	.03	.00	.00	.06	.00	.00	.03	.03	.11
Total Kjeldahl	.41	.43	.48	.60	.51	.49	.43	.39	.47	.45	.42	.50
Nitrite	.007	.007	.010	.009	.006	.006	.007	.008	.008	.009	.007	.008
Nitrate	<.01	<.01	.01	.02	<.01	<.01	<.01	<.01	<.01	<.01	.01	.01
Total Phosphorus	.011	.013	.012	.012	.015	.018	.024	.014	.017	.016	.016	.027
Soluble "	.001	.002	.001	.001	.001	.001	.002	.002	.001	.002	.002	.004
Hardness	36	52	108	158	30	24	36	38	32	30	32	34
Alkalinity	9	11	11	13	9	9	11	11	11	11	11	11
Iron	.30	.30	.40	.40	.30	.30	.60	.25	.30	.35	.55	1.0
Acidity	6	4	8	10	12	2	4	4	4	8	8	10
pH	6.6	6.7	6.3	6.1	6.6	6.6	6.5	6.5	6.5	6.4	6.4	6.5
Sulfate	7	8	19	29	7	6	8	8	7	7	7	8
Calcium	9	18	40	55	7	7	8	7	7	8	8	8
Magnesium	3	1	2	5	3	2	4	5	3	2	3	3
Conductivity	91	108	417	620	83	82	94	84	83	92	93	97
Sodium		15				5			6			
Potassium		1.2				0.9			0.9			
Zinc ppb	10	20	50	50	20	0	30	30	10	30	20	20

Table 2 cont'd.

				6			7				8		
Analyses		0	10	20	25	0	10	20	0	10	20	30	36
Copper	ppb	<0.05	< 0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel	ppb	<0.05	< 0.05	40	120	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead	ppb	<0.05	< 0.05	< 0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	ppb	<0.05	< 0.05	< 0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cobalt	ppb	<0.05	< 0.05	< 0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese		<0.05	20	50	70	20	20	80	30	20	20	50	230

Table 3 Results of chemical analyses performed on sediment samples collected from Gordon, Werner and Grant Lakes during 1971. Values represent averages for three samples.

	% Loss on Ignition	Zinc as Zn (ppm)	Copper as Cu (ppm)	Nickel as Ni (ppm)	Lead as Pb (ppm)	Cadmium as Cd. (ppm)	Cobalt as Co (ppm)	Silver as Ag. (ppm)	Mangamese as Ma (ppm)	Iron as Fe * %
GORDON L-GO1	11	59	430	1520	0	20	79	0	511	4.1
GO2	16	85	215	548	0	10	29	0	381	3.0
GO3	12	102	339	1330	0	20	54	0	526	4.3
WERNER L-W4	22	102	29	58	0	20	19	0	581	2.5
W5	21	111	58	50	0	10	16	0	499	2.4
W6	18	158	568	1134	0	20	47	0	332	3.2
W7	17	109	56	54	0	20	32	0	468	2.5
GRANT L-GR8	21	127	65	72	0	20	42	0	501	2.7

* 1% Equivalent to 10,000 ppm

Table 4 Concentrations of Heavy Metals in Muscle, Liver, Brain, Scales and intestines of Fishes taken from Gordon Lake, June 24, 1971.

SPECIES	Length (cms)	Weight (gms)	Sample	Hg (ppm)	Cu (ppm)	Zn (ppm)	Pb (ppm)	Ni (ppm)	Cd (ppm)
WALLEYE	23.0	190	Muscle	0.44	0.00	3.07	0.00	0.00	0.00
	30.5	360	Muscle	0.57	0.00	2.92	0.00	0.00	0.00
	44.4	1070	Muscle	0.57	0.23	1.62	0.00	0.00	0.00
	23.0	190	Liver	-	0.00	19.80	0.00	0.00	0.00
	30.5	360	Liver	-	0.00	19.40	0.00	0.00	0.00
	44.5	1070	Liver	-	3.47	17.60	0.00	0.99	0.00
	23.0	190	Brain	-	0.00	41.00	0.00	0.00	0.00
	30.5	360	Brain	-	0.00	3.10	0.00	0.00	0.00
	44.4	1070	Brain	-	0.00	0.00	0.00	17.00	0.00
	23.0	190	Skin & Scales	-	0.00	41.20	0.00	0.00	0.00
	30.5	360	Skin & Scales	0.04	4.20	63.00	6.30	4.20	1.57
	44.4	1070	Skin & Scales	-	3.57	61.50	0.00	8.04	0.00
	23.0	190	Intestines	-	0.00	21.90	0.00	0.00	0.00
	30.5	360	Intestines	-	0.00	18.50	0.00	0.00	0.00
	44.4	1070	Intestines	0.13	0.00	17.65	0.00	0.58	0.00
WHITEFISH	30.5	390	Muscle	0.19	0.00	3.43	0.00	0.00	0.00
	44.5	2070	Muscle	0.13	0.00	3.14	0.00	0.00	0.00
	45.0	1510	Muscle	0.14	0.00	3.36	0.00	0.00	0.00
	48.0	1930	Muscle	0.14	0.30	4.40	0.00	0.00	0.00
	48.0	2070	Muscle	0.19	0.30	5.28	0.00	0.00	0.00
	48.5	2120	Muscle	0.14	0.00	3.02	0.00	0.00	0.00
	51.0	2370	Muscle	0.11	0.00	2.30	0.00	0.49	0.00
	54.5	2680	Muscle	0.13	0.00	3.77	0.00	0.00	0.00
	30.5	390	Liver	-	0.00	20.50	0.00	0.00	0.00
	44.5	2070	Liver	0.23	2.60	22.90	0.00	0.00	0.00
	45.0	1510	Liver	0.17	2.48	23.60	0.00	0.00	0.00
	48.0	1930	Liver	0.18	5.10	21.40	0.00	0.00	0.00
	48.0	2070	Liver	0.20	3.60	23.21	0.00	0.00	0.00
	48.5	2120	Liver	0.18	5.30	15.20	0.00	0.00	0.00
	51.0	2370	Liver	0.16	9.13	18.50	0.00	0.98	0.00
	54.5	2680	Liver	-	9.60	16.90	0.00	0.00	0.00
	44.5	2070	Brain	-	0.00	1.10	0.00	0.00	0.00

Table 4 cont'd.

SPECIES	Length (cms)	Weight (gms)	Sample	Hg (ppm)	Cu (ppm)	Zn (ppm)	Pb (ppm)	Ni (ppm)	Cd (ppm)
WHITEFISH	45.0	1510	Brain	-	0.00	56.20	0.00	0.00	0.00
	48.0	1930	Brain	0.09	2.65	12.70	0.00	0.00	0.00
	48.0	2070	Brain	-	0.00	28.60	0.00	0.00	0.00
	48.5	2120	Brain	-	0.00	32.10	0.00	0.00	0.00
	54.5	2680	Brain	-	0.00	20.80	0.00	0.00	0.00
	30.5	390	Scales	0.07	0.00	71.00	0.00	2.53	0.00
	44.5	2070	Scales	0.10	0.00	77.00	0.00	1.78	0.00
	45.0	1510	Scales	0.18	0.49	66.00	0.00	2.08	0.37
	48.0	1930	Scales	0.05	0.98	52.30	2.93	1.70	0.49
	48.0	2070	Scales	0.03	1.00	32.00	3.00	1.43	0.29
	48.5	2120	Scales	0.05	0.66	65.80	2.37	0.92	0.26
	51.0	2370	Scales	0.43	0.53	84.50	1.58	2.12	0.43
	54.5	2680	Scales	0.04	0.52	39.60	3.10	1.72	0.69
	30.5	390	Intestines	-	0.94	68.80	0.00	1.69	0.00
	44.5	2070	Intestines	0.10	9.71	61.20	0.00	1.10	0.00
	45.0	1510	Intestines	0.09	8.30	65.90	0.00	2.21	0.00
	48.0	1930	Intestines	-	0.00	51.70	0.00	0.00	0.00
	48.0	2070	Intestines	0.10	6.10	32.40	0.00	0.00	0.30
	48.5	2120	Intestines	0.67	4.50	62.20	0.00	0.00	0.00
	51.0	2370	Intestines	0.18	6.20	74.00	0.00	0.52	0.00
	54.5	2680	Intestines	0.06	1.28	21.90	0.00	0.00	0.00

Table 5 Bottom Fauna data secured from eight locations on Gordon, Werner and Grant Lakes, June 23 and 24, 1971. Results are expressed in number of organisms per square feet.

	1	2	3	4	5	6	7	8
MAYFLIES								
Hexagenia					1			
ALDERFLIES								
Sialis		<1						
DIPTERA								
Tendipedidae	9	2	17	38	23	2	3	14
Heleinae		<1						
Chaoborus	4	2	1	1		4	13	57
Sp. pupa	<1	<1	1			2	1	15
AMPHIPOD								
Ponoporeia affinis					4			
DECAPOD								
Mysis relicta					1			
MULLUSCA CLAMS								
Pisidium							1	
Sphearium				1	8	<1		
ROUND WORMS								
Oligochaeta	7	15	2	1	3	15		
Total Taxa	4	6	4	4	6	5	4	3

Table: 6 Summary of phytoplankton data collected from Gordon and Werner Lakes, June 23, 1971. All results are expressed as areal standard units per millilitre.

	Gordon Lake Station 2	Gordon Lake Station 3	Werner Lake Station 4	Werner Lake Station 5	Werner Lake Station 6
Blue-greens					
Anabaena			45	5	64
Chrococcus	10		3	15	2
Gomphosphaeria					336
Lyngbya	15			3	
Aphanocapsa			P		
Aphanothece				72	
Merismopedia					
Total	25		48	95	432
Flagellates					
Chlamydomoaas	12	6	9	6	11
Cryptomonas	37	75		5	6
Dinobryon				3	3
Glenodinium					
Peridinium			5	7	
Synura					3
Trachelomonas			2		
Chrysophyte	33	33	33	15	25
Rhodomonas	11	6	72	54	62
Mallomonas				11	
Total	93	120	121	101	110
Greens					
Ankistrodesmus	2	2	1	15	7
Cosmarium	302		1		
Oocystis			19	3	3
Pediastrum				5	
Scenedesmus			3	1	3
Sphaerocystis		3	16		
Staurastrum			9		
Characium	2				
Selenastrum				2	1
Crucigenia				6	4
Total	306	5	49	32	19
Diatoms					
Asterionella	884	1688	35		68
Cyclotella	12		17	14	12
Fragilaria	165	148			
Melosira	2			7	
Navicula	2		2		
Nitzschia	6	6			
Stephanodiscus			12		
Synedra	171	139			2
Achnanthes			2		
Rhizosolenia			28	44	59
Total	1242	1981	96	65	141
Grand Total	1666	2106	314	293	702

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